BEHAVIOUR OF STEEL FIBER REINFORCED CONCRETE AND HIGH PERFORMANCE CONCRETE EXPOSED TO ELEVATED TEMPERATURE

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I/We* hereby declare that I/We* have checked this thesis/project* and in my/our* opinion, this thesis/project* is adequate in terms of scope and quality for the award of the Bachelor Degree of Civil Engineering

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Konkrit bertetulang gentian keluli (SFRC) dan konkrit prestasi tinggi (HPC) digunakan secara meluas dalam unsur-unsur struktur bangunan seperti lata, lantai perindustrian dan lain-lain dengan meningkatkan sifat-sifat mekanikal struktur bangunan. Secara amnya, suhu tinggi adalah masalah yang serius bagi semua struktur konkrit dan merosakkan kesan pada tahap struktur akibat pendedahan kepada api, jika berlaku kebakaran. Dalam kerja percubaan ini mempunyai aspek yang menumpukan kepada suhu tingkah laku konkrit asas konkrit pada suhu tinggi termasuk kekuatan sisa. Selepas tertakluk kepada suhu pemanasan tinggi yang berbeza, antara suhu bilik dan 240°C, kekuatan konkrit bertetulang yang diperkuat dengan gentian keluli 4% (SFRC) dan kekuatan residu konkrit (HPC) yang tinggi telah disiasat. Bagi setiap jenis konkrit 18 set untuk konkrit biasa (PC), konkrit prestasi tinggi (HPC) dan konkrit bertetulang gentian keluli (SFRC) kiub telah dibuat. Spesimen-spesimen ini telah diuji untuk kekuatan mampatan pada suhu tinggi iaitu suhu bilik dan 240°C selama satu jam dalam keadaan panas sebaik sahaja keluar dari oven. Keputusan dianalisis dan kesimpulan akhir diambil.

ABSTRACT

Steel fiber reinforced concrete (SFRC) and high performance concrete (HPC) are widely used in the structural elements of buildings such as slabs, industrial floors and others by enhancing the mechanical properties of structural elements of buildings. Generally, high temperature is serious problems for all concrete structures which drive in a mechanical decay of the concrete and even damaging effects at the structural level due to exposure to the flames, in case of fire. In this experimental work has an aspect which focused on basic mechanical behavior of concrete at high temperature including residual strength. After being subjected to different elevated heating temperatures, ranging between room temperature and 240ºC, the compressive strength of concrete reinforced with 4% steel fiber reinforced concrete (SFRC) and high performance concrete (HPC) residual strength have been investigated. For each type of concrete 18 sets for plain concrete (PC), high performance concrete (HPC) and steel fiber reinforced concrete (SFRC) of cubes have been cast. These specimens have been tested for compressive strength at elevated temperatures of room temperature and 240ºC for one hour in hot condition immediately after taking out from oven. The results are analysed and final conclusion are drawn.

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LIST OF ABBREVIATIONS

HPC	High performance concrete
SFRC	Steel fiber reinforced concrete
PC	Plain concrete
SC	Standard concrete
FRSC	Fiber reinforced standard concrete
DoE	Design of experiments
OPC	Ordinary Portland cement
BS	British standard

CHAPTER 1

INTRODUCTION

1.1 Background

The construction industry mostly uses steel fiber reinforcement in high performance concrete in applications such as tunnel lining and road paving. High performance concrete (HPC) is one of more durable and stronger materials concreted compare to conventional concrete due to the admixtures used in its proportion such as fly ash, super plasticizers and silica fume. The term ‘High performance concrete’ is also used because the mixture and proportion of this concrete are incompatible with conventional concrete. Hence, HPC is designed with high strength, high modulus elasticity, high durability and long life in severe environment. Steel fibre reinforced concrete can be designed as a composite material made with Portland cement, aggregate, and discrete discontinuous steel fibres. The real contribution of the steel fibre is to increase flexural, compress, tensile, and shear strength; toughness, and crack resistance by enhancing the properties of steel fibre reinforced concrete composite material.

Generally, the structural member design need to fulfil the requirements of serviceability and safety limit states for various environmental conditions. Fire is one of the major problems for high performance concrete structural members. This is because high performance concrete cannot sustain high temperature at extended periods of time. Although steel fibre doesn’t provide positive impact from fire-endurance point of view; based on previous research, it has been concluded that steel fibers have an impact on the spread of cracking and improve the performance of concrete after exposure to elevated temperature.

The performance of a concrete structural member exposed to fire is subject to thermal, mechanical and deformation properties of concrete of which the member is composed.

As a result, the properties of concrete change significantly within the members corresponding with building fires. The effect of temperature on these properties is different hence, it depends on the composition and characteristics of concrete. At both room and high temperature, the strength of concrete has significant impact due to its properties and the properties of high performance concrete (HPC) vary more with temperature compared to conventional concrete. This change is significantly more to mechanical properties that are influenced by strength, moisture content, density, heating rate, amount of silica fume and porosity.

In practice, fire resistance of structural members is evaluated mainly through the standard fire test, which is performed according to the specifications given by IS standard. When a structural member is subjected to a defined temperature-time exposure during a fire, this exposure will cause a predictable temperature distribution in the member. Increased temperatures cause deformations and property changes in the constitutive materials of a structural member.

1.2 Problem Statement

Usually the strength of the steel fiber decreases under high temperature and this happens during fire hazard. The strength of the steel fiber will reduces when burning. So, in order to investigate the performance of steel fiber reinforcement in high performance concrete (HPC) at elevated temperature, it is necessary that fire resistance tests for different elevated temperatures are conducted.

1.3 Research Objectives

The objective of this research study is to generate experimental data to aid the provision of a fire resistance rating for steel fiber reinforced concrete in high performance concrete (HPC). The main objectives are:

1. Study the effect on steel fiber reinforced concrete (SFRC) of exposure to elevated temperatures.

2. Study the behaviour of high performance concrete (HPC) at elevated temperature.

1.4 Scope of Work

The study will do the testing analysis for the steel fiber reinforced high performance concrete where exposing them to elevated temperatures at room temperature and 240ºC. All the specimens will be test in the laboratory. The experiment study included 18 cubes of 150 mm size for each type of concrete of which steel fiber reinforced concrete and high performance concrete. The compressive strength tests will be supervise to know the strength properties of the mixes.

Samples	SFRC		HPC		PC	
Compressive Test	Room temp.	240º C	Room temp.	240º C	Room temp.	240º C
	3	3	3	3	3	3

Table 1.4.1: Number of specimens for each test

Principles of DoE method of mix design used to estimate the concrete mix proportion. Concrete mix proportion is 1:1.5:4 with water cement ratio of 0.47. The cement use is Ordinary Portland Cement (OPC). The fine aggregate use is 70% passing 600 µm sieve (uncrushed) with uncrushed maximum aggregate size of 20 mm. The test use is 30 N/mm² of characteristic compressive strength at 28 days. Next, provide straight fibers of 0.5 mm diameter and 50 mm length with 4% fibers by weight of concrete is added to the concrete mix (standard concrete).

Mixes	Quantity per m³ of concrete	
	Standard Concrete	Standard Fiber Reinforced Concrete
Cement	340 kg	340 kg
Fine Aggregate	515 kg	515kg
Coarse Aggregate	460 kg (10 mm) 925 kg (20 mm)	460 kg (10 mm) 925 kg (20 mm)
Fibers	-	96 kg
Super-plasticizer	2.05 L	2.05 L
Water	160 L	160 L

Table 1.4.2: Total quantities used in experimental work

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